"A systematic approach for aircraft on-board system architecture within DEFAINE"

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ITEA3

17th MODPROD Workshop 7-8th Febr 2023, Linköping, Sweden

Agenda

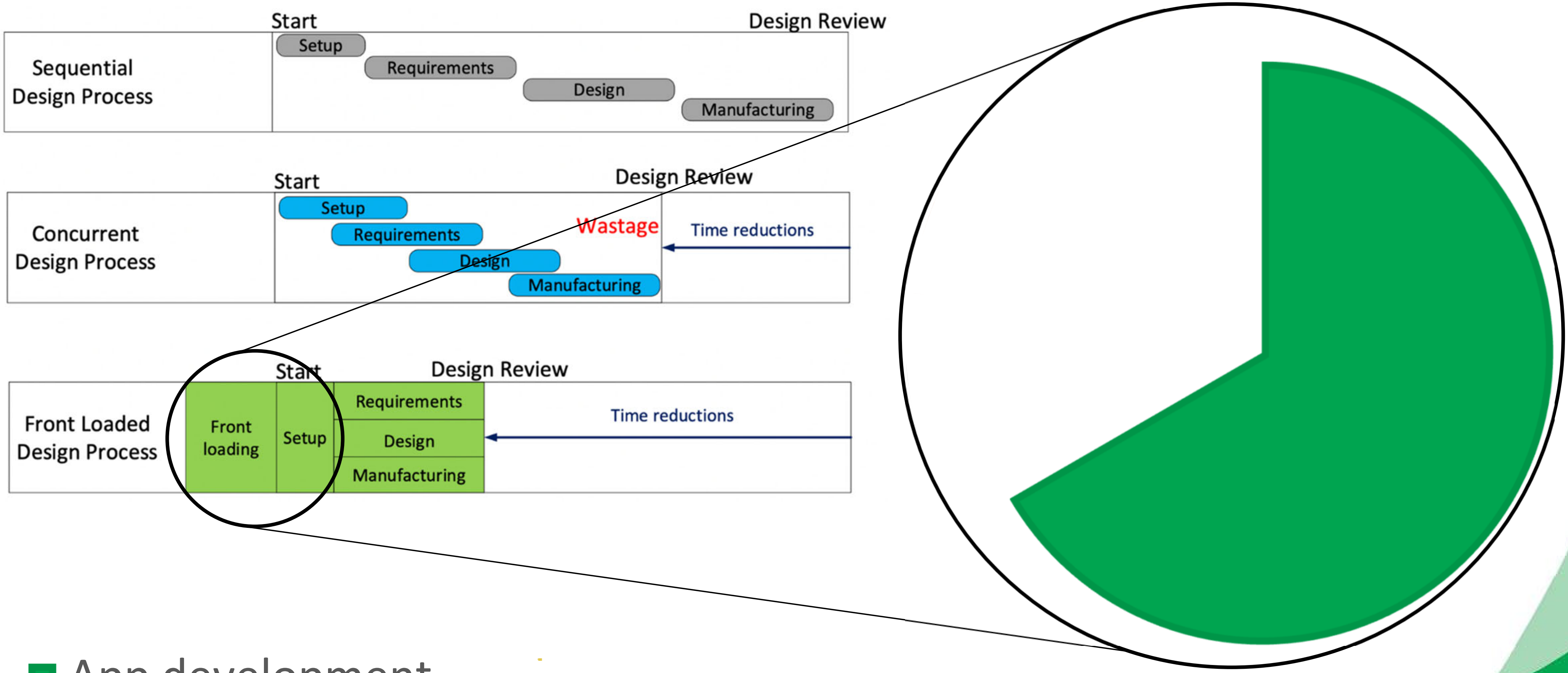
- DEFAINE overview
- On-Board System use case
  - Architecture generation
  - Time domain model automation
- Conclusion and future work

DEFAINE Objectives

- To reduce recurring cost in the design of aerospace systems and reduce the lead-time for design updates
- By enabling AI-powered front-loading
- Via a software framework that allows design engineers to perform large-scale design exploration studies

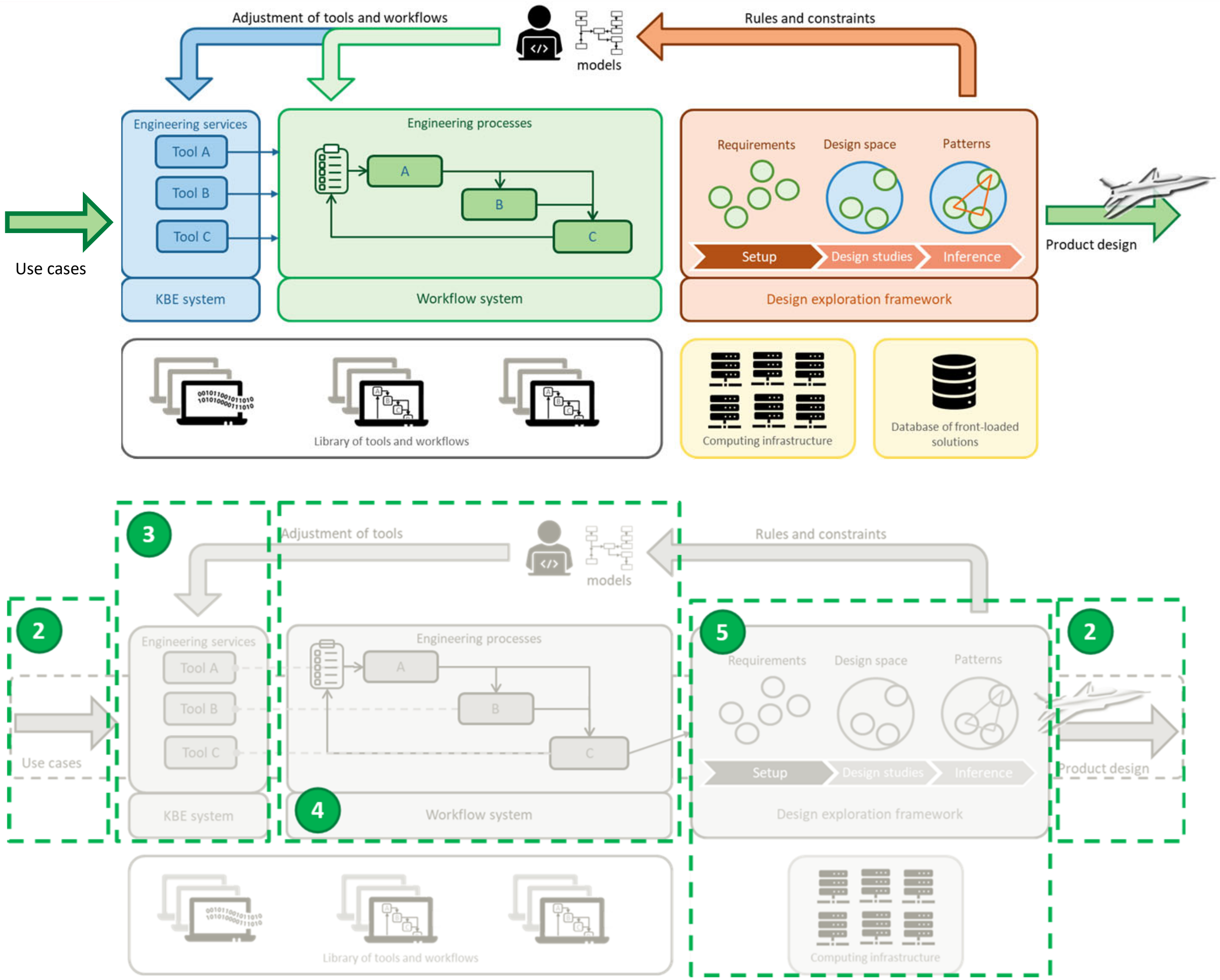
- Goals:
  - 10% cost reduction during design phase of aerospace systems
  - 50% lead-time reduction for design updates

DEFAINE goals: Front loading



- App development

DEFAINE Overview



WP 2. Industrial use cases
WP 3. Engineering services and development methodologies
WP 4. Workflows and data exchange standards
WP 5. Design space exploration and AI

WP 1: Project Coordination
WP 6: Dissemination and exploitation

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DEFAINE Partners

Fokker

GKN AEROSPACE

PE | GEOMETRY

KE-works

ParaPy

LINKÖPING UNIVERSITY

TU Delft

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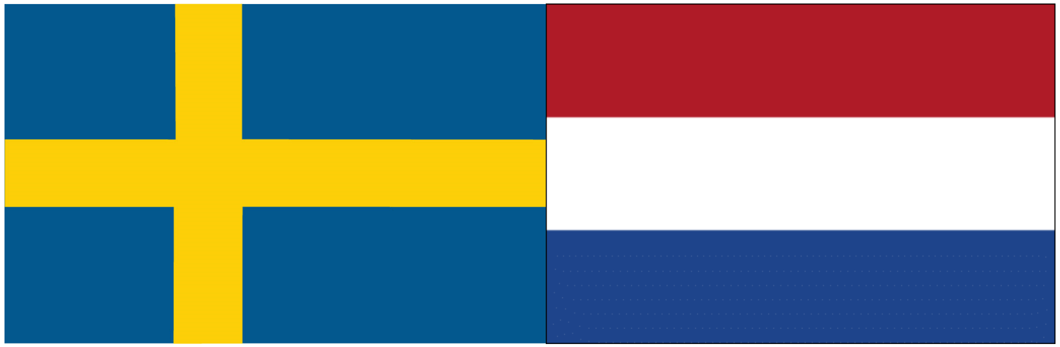
SAAB



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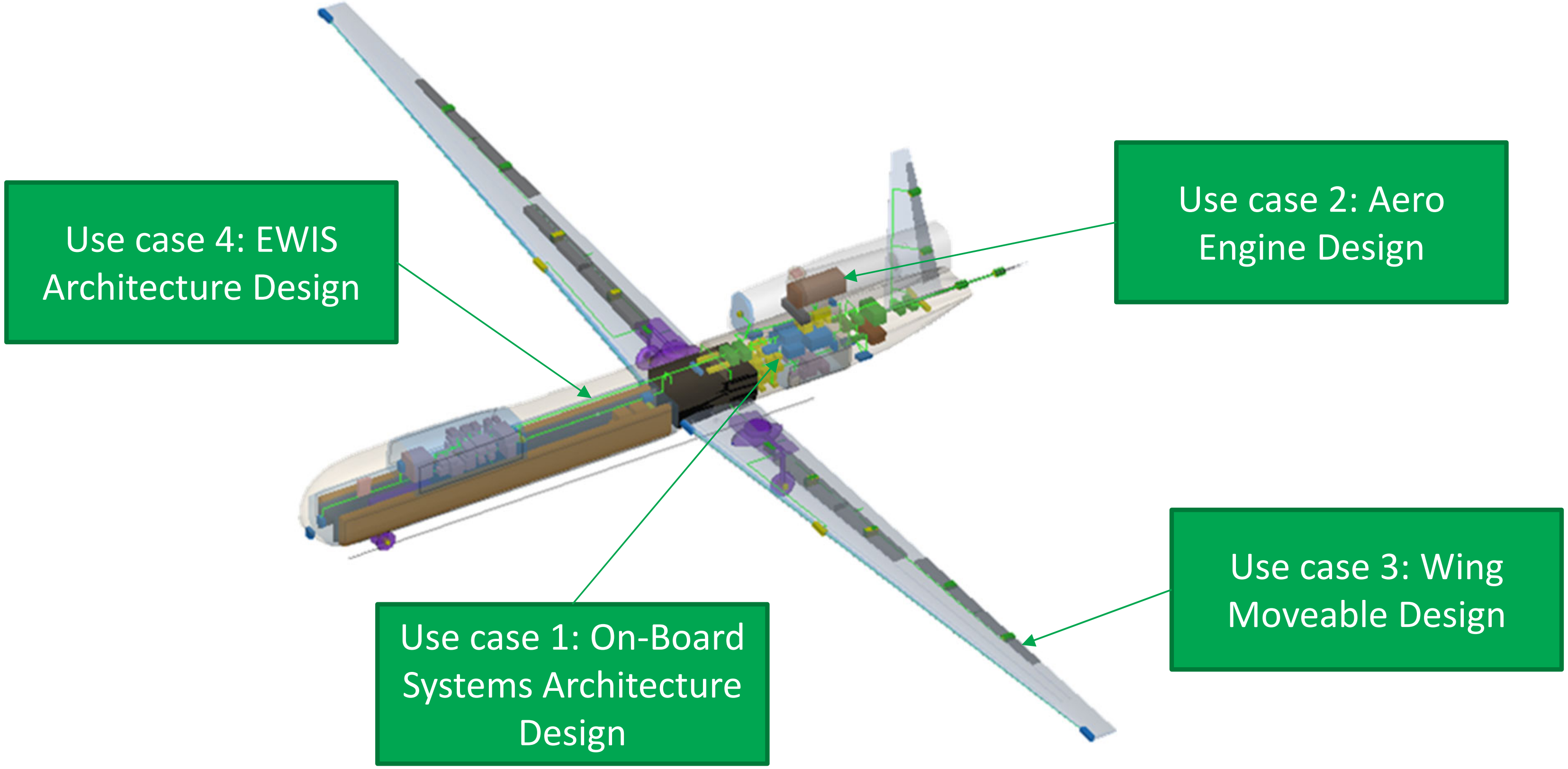
Industrial use cases



On-Board system use case

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Background & Use-Case Description

Backgorund:

- UAV overall design
  → early design stage
- Current development process based on point assessment / steady-state models
- Engineering tool/environment: PaceLab®
- Main Objective:
  - DSE for global vehicle configuration
  - Selection/Combination of on-board systems

Use Case Objective:

- Enable higher fidelity dynamic model of the on-board system, based on the design/vehicle information defined within the PaceLab®-based ACD process.
- By making use of a semi-automated KBE process containing:
  a) system architecture design inf.,
  b) subsystem sizing (domain specific), and
  c) simulation tool specific information

Background: Aircraft On-board Systems

- Power systems
- Specific domains: hydraulic, pneumatic, electric, (mechanic)
- System interdependencies
- Redundancy / Reliability
- Systematic split-up:
  - power generation (PGS)
  - power distribution (PDS)
  - power consumption (PCS)

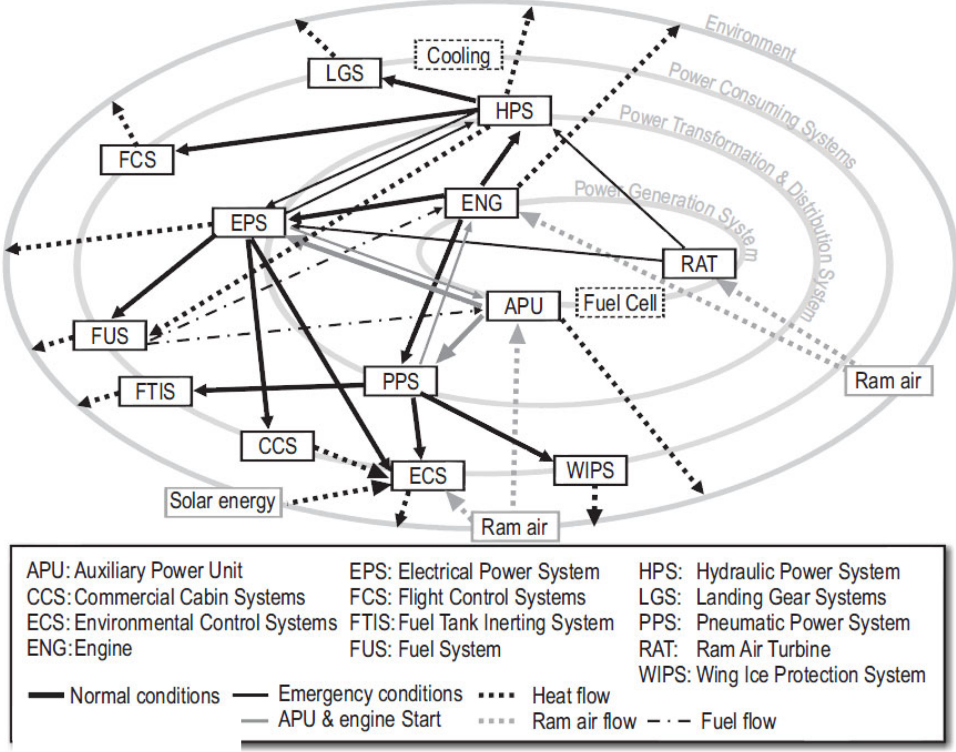


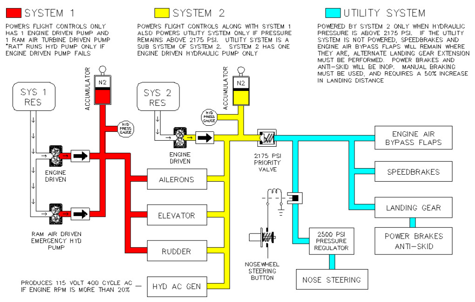
Figure 3.3: Energy flow overview for a conventional power systems architecture

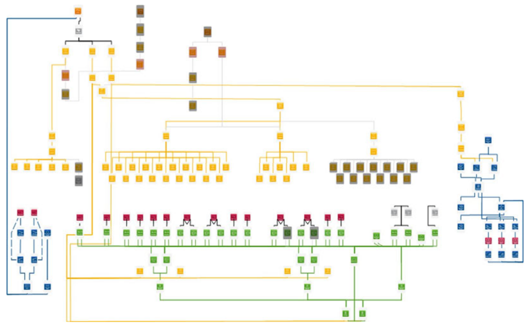
source: Liscouët-Hanke, *A model-based methodology for integrated preliminary sizing and analysis of aircraft power system architecture*, 2008.

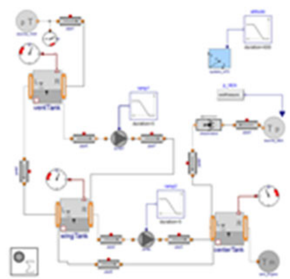
On-Board Systems Architecture Design

- Creation of architecture is done manually
  - Time consuming
  - None added value
  - Prone to error
- Implementation of the different architectures is done manually component per component…
- Automate architecture creation and instantiation
  - KBE rules
  - Ease of implementation
  - Ease of modification

Current way of working







Architecture and technology

Steady State

Time Domain

On-Board system architecture automation

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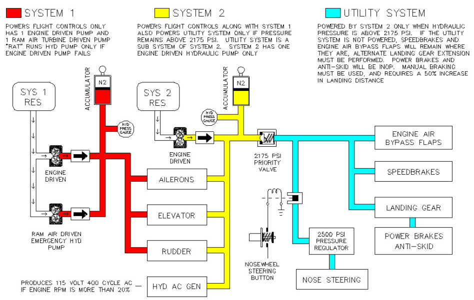
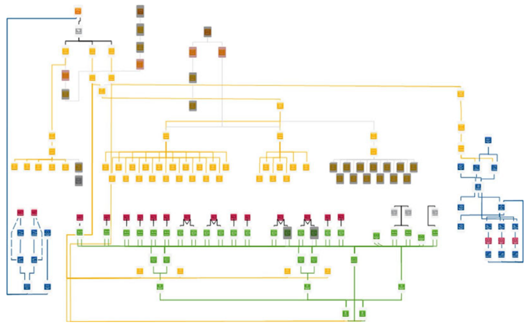
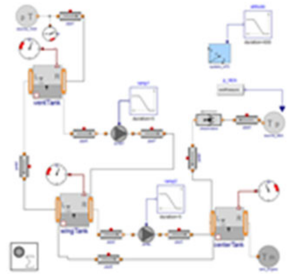
Envisioned way of working







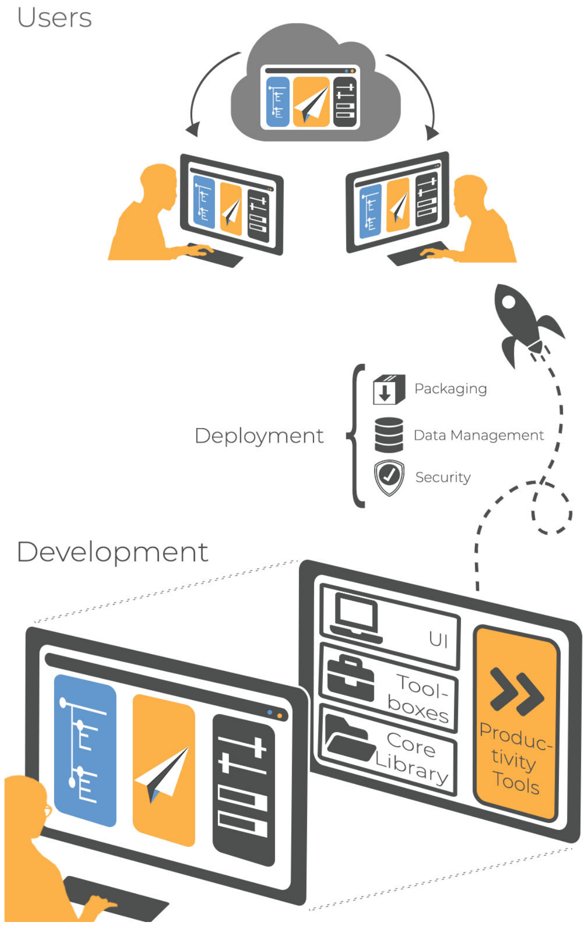
Architecture and technology

Steady State

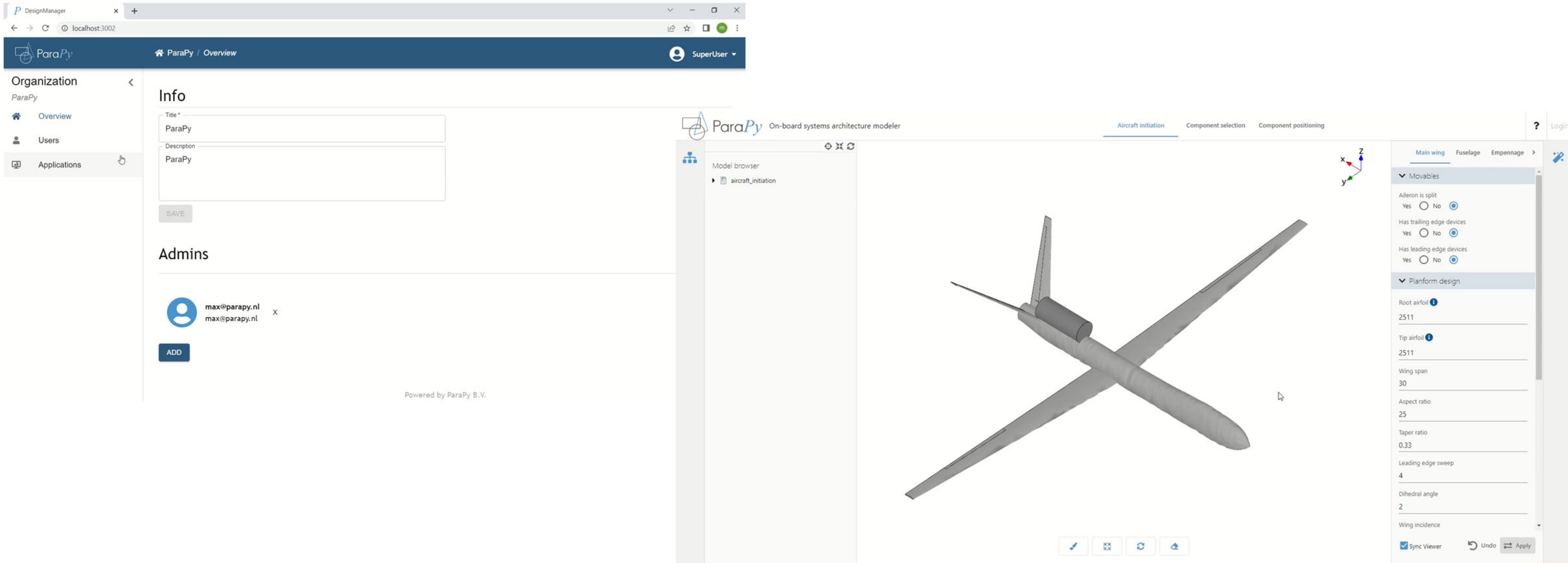
Time Domain

Approach

- Define logic for each type of system
  - Rules
  - Logical step
  - Input format to PaceSysArc
- Make usage of KBE environment offer by ParaPy
  - Ease of KBE app development
  - Ease of deployment: cloud



Assystor app overview

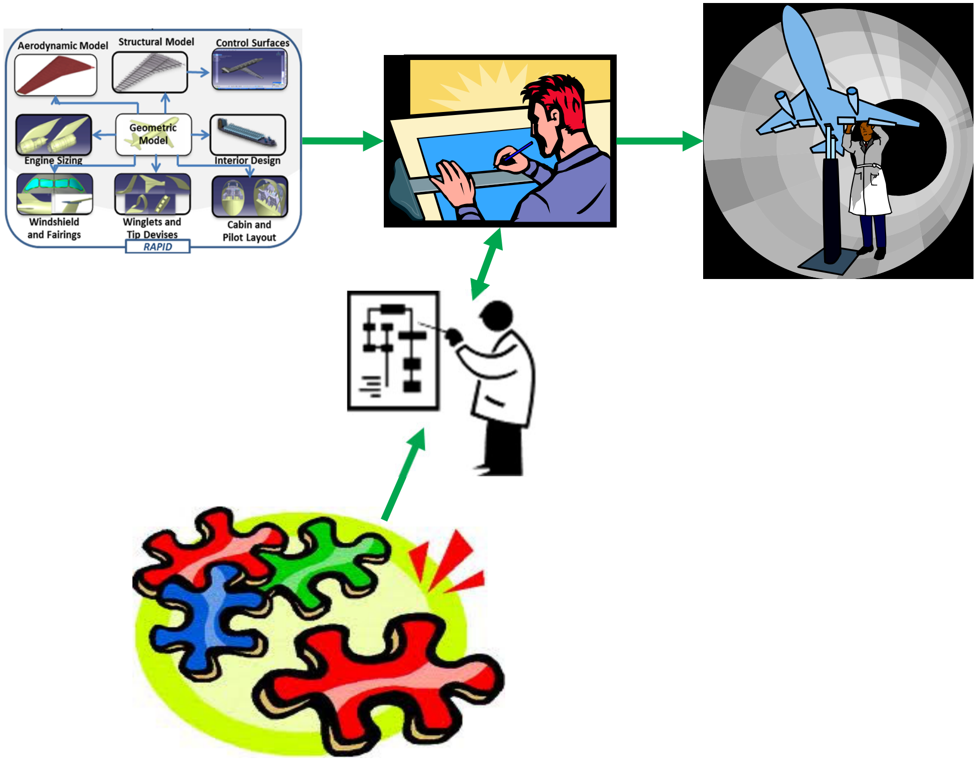


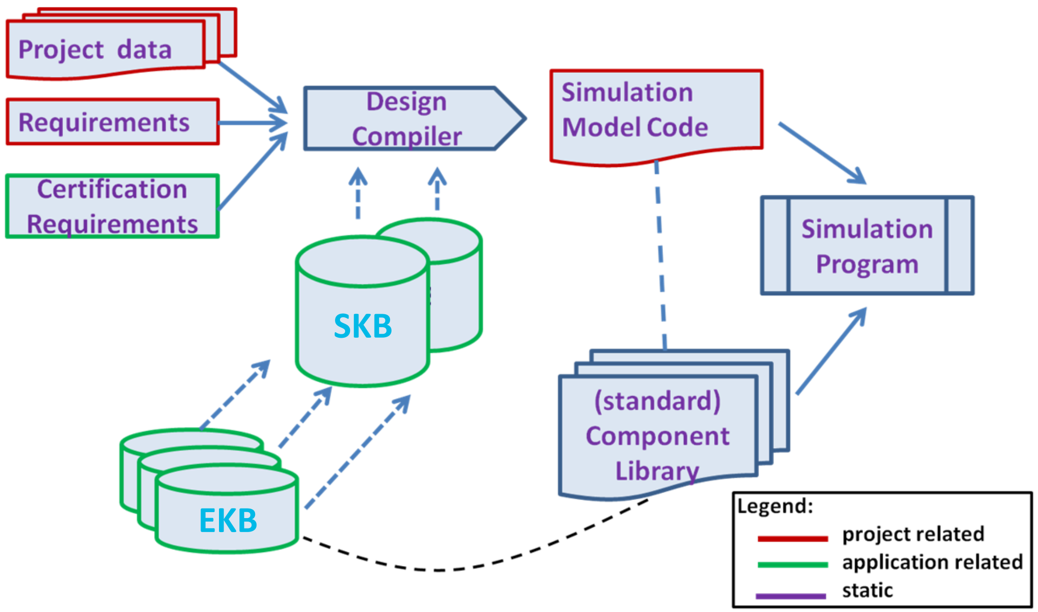
Current achievement architecture generation

- Automatic generation of FCS architecture with regards to:
  - Nb of control surfaces
  - Redundance level
  - Technology choices
- Time reduction
  - About 40 times quicker so far:
    - Still some manual work at the import in Pace SysArc
  - Enables quicker exploration of different architectures
- No full automation of architecture generation to design space exploration realised yet
  - Will lead to further reduce of time
  - Automated import will further reduce the time from architecture creation to usage with a factor of ~30

III. KBE-based process to enable higher-fidelity (dynamic) model in the early design stage

General Approach:
Tool-specific Simulation-integrating KBE Approach

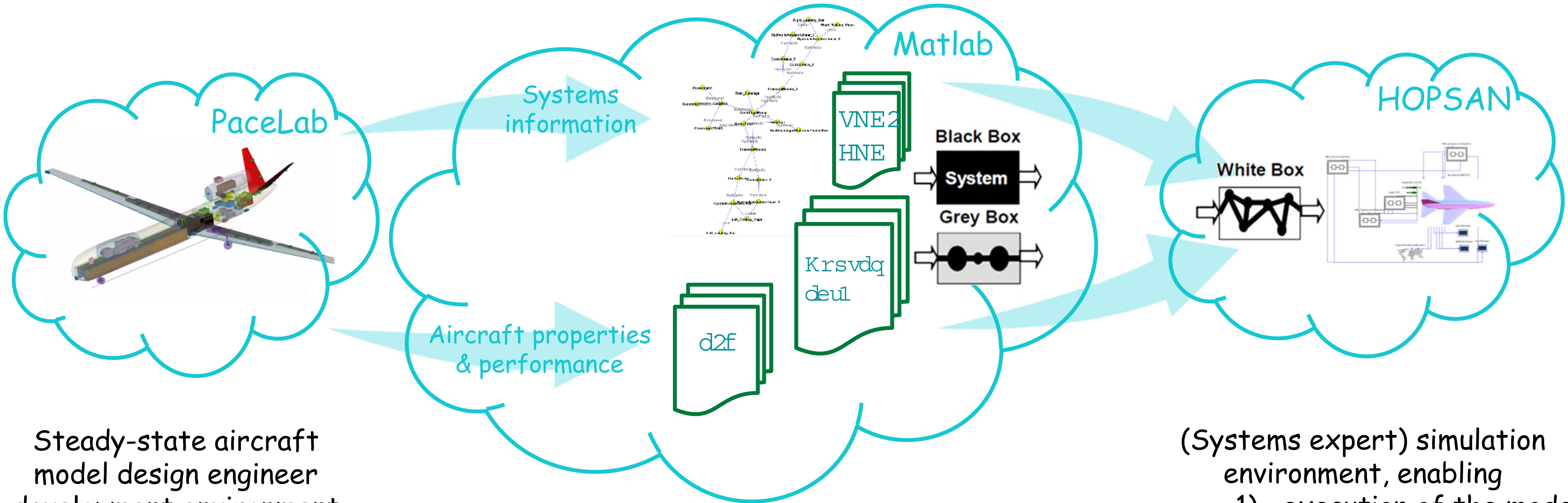




SKB: System Knowledge Base
EKB: Element Knowledge Base

- serve for the translation from meta-components towards the simulation components in the library

Use-Case Specific Implementation

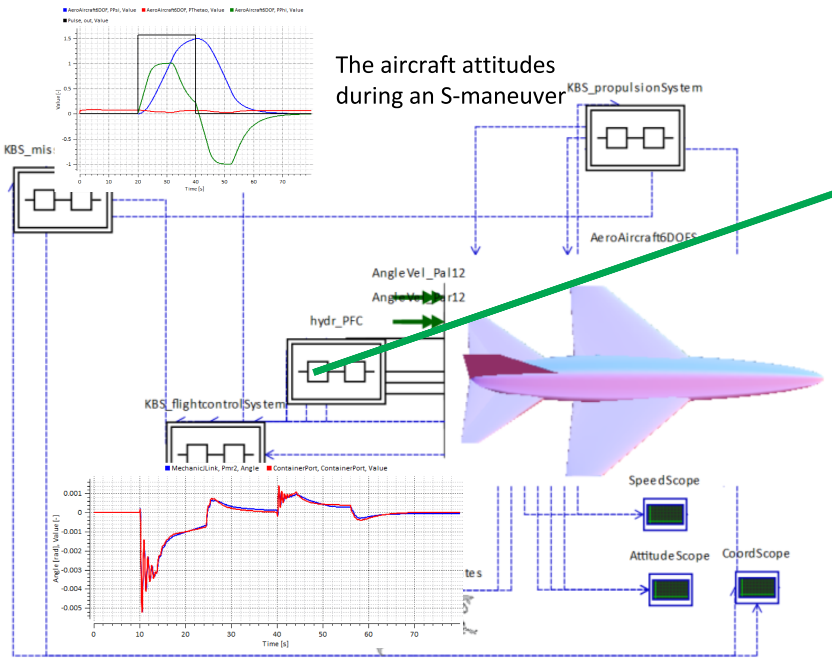


Steady-state aircraft model design engineer development environment

Design interpreter and model generator:
1) input format (PaceLab) parser
2) KBE rule base
3) meta model of the sim. environment logic, structure, format, and library

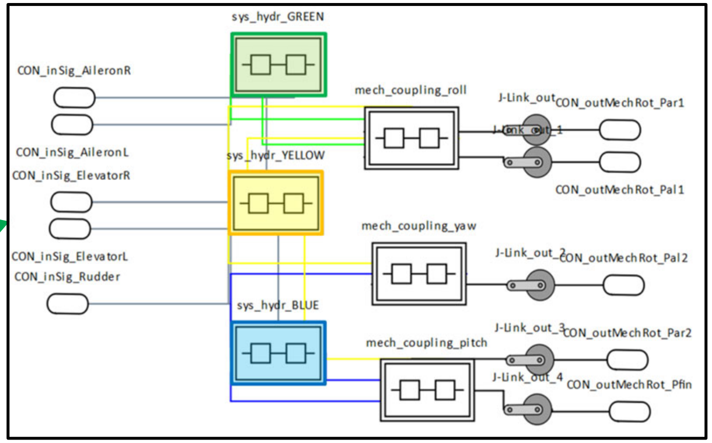
(Systems expert) simulation environment, enabling
1) execution of the model
2) analysis & optimization
3) ToDo: advanced auto-tuning routines

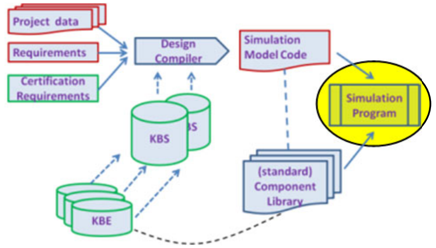
Realized Simulation Model

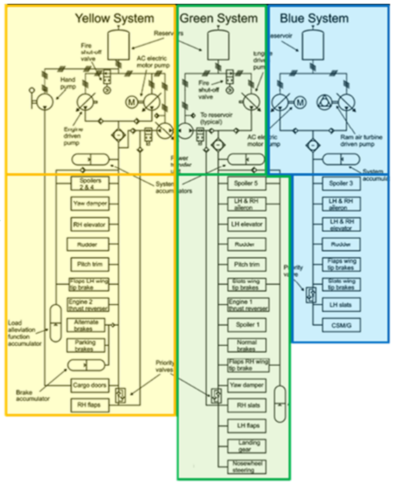


The aircraft attitudes during an S-maneuver

Angular position and reference position of the rudder actuator







Conclusion

- A prototype to automate the on-board system architecture creation has been created and validated
  - Showing a time reduction of more than 40 times!
  - Further development is needed to cover more systems
- Integration to the time domain is under development
  - Extraction of flight condition specific information
  - Transformation of the steady state model to time domain
  - Enabling interoperability through standard (SSP, FMU/FMI)